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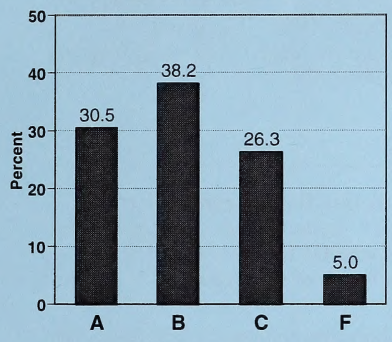
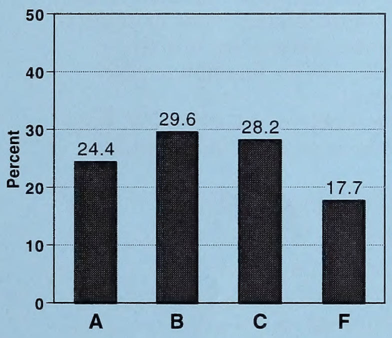
Physics 30

Diploma Examination Results
Examiners' Report for January 1999

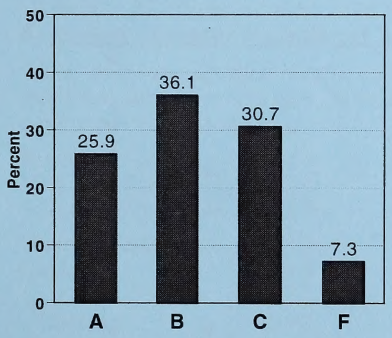
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the January 1999 administration of the Physics 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, June, and August results is made available annually.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 53%, 12 numerical-response questions worth 17%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported below is based on the final course marks achieved by 3 420 students in Alberta who wrote the January 1999 examination.

- 92.7% of the 3 420 students achieved the acceptable standard (a final course mark of 50% or higher).
- 25.9% of students achieved the standard of excellence (a final course mark of 80% or higher).

Students are demonstrating improved skills in addressing all aspects of the written-response questions. However, students have difficulty communicating their understanding of the physics used to solve the problem. Students are attempting to use previously obtained results to answer a linked item. Students must pay particular attention to recording their answers to numerical response questions correctly. In particular, students must ensure that they record the correct number of digits, and that they record their response in the required format. Students' attention should be directed to the numerical-response examples provided in the instructions for the Physics 30 Diploma Examination.

Approximately 35.7% of the students who wrote the examination were female. Of these, about 93.6% achieved the acceptable standard for a final course mark, compared with 92.1% of the male students. Approximately 27.0% of the female students achieved the standard of excellence, compared with 25.3% of male students. The average examination mark achieved by the female students was 66.4%, and the male students achieved an average mark of 65.7%.

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Provincial Averages

- The average school-awarded mark was 70.8%.
- The average diploma examination mark was 66.0%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 68.7%.

Approximately 5.8% of the students who wrote the examination in January 1999 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the January 1998 to January 1999 period. This subpopulation (198) achieved an examination average of 61.5%, compared with 66.3% for the population (3 222) who first wrote the Physics 30 examination in January 1999. The group of students who rewrote increased their examination score on average by 11.3%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations (GLE). Even though some questions address more than one GLE, only one GLE was selected for the purpose of this report.

Knowledge:

GLE 1 Explain gravitational, electrical, and magnetic effects on systems
GLE 2 Analyze and predict the behaviour and physical interactions of objects
GLE 3 Describe and analyze resistive circuits and the function of EM devices
GLE 4 Solve problems related to EM wave behaviour and the atomic theory

Skills:

SPC Scientific Process Skills & Communication Skills

Science, Technology, Society:

STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC1	B	0.795		✓				✓
NR1	7.07	0.898		✓			✓	
MC2	C	0.699		✓				✓
MC3	A	0.689		✓				✓
MC4	D[*]	0.574		✓				✓
MC5	B	0.694		✓			✓	
MC6	B	0.892		✓				✓
NR2	3.01[†]	0.445		✓				✓
MC7	B	0.680		✓				✓
NR3	3.27[‡]	0.705		✓				✓
MC8	D	0.727		✓				✓
MC9	B	0.685		✓				
MC10	C	0.663		✓			✓	✓
NR4	1.17[§]	0.731		✓				✓
MC11	B	0.699		✓				✓
MC12	C	0.794		✓				✓
MC13	B	0.685	✓					
MC14	D	0.414	✓				✓	
NR5	6.00	0.766			✓			✓
NR6	3.00[‖]	0.908			✓			✓

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC15	B	0.684	✓					✓
MC16	D	0.864			✓			✓
NR7	1818[#]	0.597		✓				✓
MC17	A	0.900			✓			
MC18	D	0.927	✓				✓	
MC19	B	0.604	✓				✓	
MC20	B	0.556	✓				✓	✓
NR8	7594	0.600		✓				
MC21	C	0.812				✓		✓
MC22	A	0.854				✓		
NR9	3.72	0.582				✓		
NR10	4.97	0.571				✓		✓
MC23	C	0.494	✓				✓	
MC24	A	0.704				✓		
MC25	A	0.890				✓		
NR11	256	0.632		✓				
MC26	D	0.608		✓				
MC27	D	0.323				✓		✓
MC28	C	0.877				✓		
NR12	2811	0.640				✓		
MC29	C	0.907				✓	✓	
MC30	C	0.568				✓		
MC31	A	0.592	✓				✓	
MC32	B	0.415		✓				
MC33	A	0.859		✓			✓	
MC34	B	0.611				✓		
MC35	D	0.733	✓					
MC36	A	0.694				✓		
MC37	D	0.807				✓		
WR1	—	0.666			✓	✓		✓
WR2	—	0.541	✓	✓			✓	

[*] MC4: A if D was selected from MC3; B if C was selected; C if B was selected, and D if A was selected

[†] NR2: 1.11 if A was selected from MC6; 3.01 if B was selected; 4.95 if C was selected, and 2.63 if D was selected

[‡] NR3: 2.11 or 2.16 if A was selected from MC7; 3.27 if B was selected; 4.55 or 4.50 if C was selected, and 6.32 or 6.19 if D was selected

[§] NR4: 2.66 if A was selected from MC10; 1.97 if B was selected; 1.17 if C was selected, and 3.13 if D was selected

[‖] NR6: equals NR5 × 0.5

[#] NR7: 1112 if A was selected from MC16; 1115 if B was selected; 1815 if C was selected, and 1818 if D was selected

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average scores.

Machine Scored	69.5%
Multiple choice	70.2%
Numerical response	67.3%
Written Response	57.7%**
Question 1	68.9%
Communication	79.5%
Content	62.9%
Question 2	46.2%

** Individual student scores for Question 1 and Question 2 are each weighted 15% of the total exam.

Average Percentage Scores and Total Test Weighting in Percentage by General Learner Expectation

		Average	*Weighting*
GLE 1	Explain gravitational, electrical, and magnetic effects on systems	59.8%	15.9%
GLE 2	Analyze and predict the behaviour and physical interactions of objects	62.3%	44.9%
GLE 3	Describe and analyze resistive circuits and the function of EM devices	76.1%	13.7%
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	70.4%	25.6%
SPC	Scientific Process Skills & Communication Skills	57.0%	30.7%
STS	Connections Among Science, Technology, & Society	69.0%	46.4%

Multiple-Choice and Numerical-Response Questions

The following table gives results for four questions selected from the examination and shows the percentage of students in four groups that answered the question correctly. The comments following the table relate to some of the understandings and skills the students may have used to answer these questions.

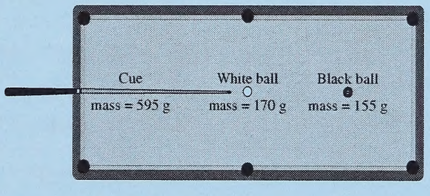
Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number			
Student Group	**MC 7**	**NR 3**	**MC 13**	**MC 27**
All Students	68.0	70.5	68.5	32.3
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	91.4	90.7	91.0	67.2
Students achieving the *acceptable standard* but not the *standard of excellence* on the whole examination	68.5	72.4	64.4	24.2
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	34.5	36.5	51.0	10.4

Use the following information to answer the next two questions.

Pool Table

An illustration depicting an overhead view of a pool table is shown below.



The pool table has rubber cushions around the playing surface so that when a ball hits the side it will be deflected back to the playing surface. A simplified analysis of the physics of playing pool assumes that Hooke's Law is valid:

$$F = -kx \text{ and } E_p = \frac{1}{2}kx^2$$

7. A pool cue with a speed of 2.30 m/s strikes a stationary white ball. The pool cue is 53.0% efficient at transferring kinetic energy from itself to the white ball. The speed of the white ball immediately after being struck is

A. 2.07m/s
***B.** 3.13 m/s
C. 4.30 m/s
D. 5.91 m/s

For **multiple-choice question 7**, most students who achieved the acceptable standard on the examination correctly answered this question. In order to obtain the correct answer, students had to equate 53.0 % of the kinetic energy of the pool cue with the kinetic energy of the white ball. Alternative C was the most frequent distracter chosen by students. To obtain the result for alternative C, the student incorrectly assumed that kinetic energy was conserved in the inelastic collision between the white ball and the cue. Alternative D was chosen by students who equated the kinetic energy of the cue to 53.0% of the kinetic energy of the white ball.

Use your recorded answer from ***Multiple Choice 7*** *to answer* ***Numerical Response 3.****

Numerical Response

3. Assume that the white ball then collides with the black ball, which was initially at rest. The white ball continues in its original direction. The speed of the white ball after the collision is 0.147 m/s. The speed of the black ball immediately after the collision is ________ m/s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

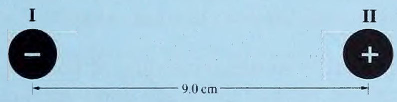
***You can receive marks for this question even if the previous question was answered incorrectly.**

Answer: 3.27

Use the following information to answer the next question.

Electrostatics

Two particles, I and II, of equal mass have opposite charges. The negative charge on particle I is three times greater than is the positive charge on particle II. The particles are placed 9.0 cm apart.



13. The electric field at a point halfway between the particles is

A. zero
***B.** toward the left of the page
C. toward the top of the page
D. toward the right of the page

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27. A light source with a wavelength of 548 nm shines on a photocell with a 1.60 eV work function. In order to have an output voltage of 12.0 V DC, the number of photocells that must be linked in series is

A. 5 photocells
B. 8 photocells
C. 10 photocells
***D.** 18 photocells

Numerical-response question 3 was linked to multiple-choice question 7. Students could receive credit for this question even if the previous question was answered incorrectly. Please refer to the examination blueprint for the acceptable answers for this linked question. Most students who achieved the acceptable standard on the examination correctly answered this question. In order to obtain the correct answer, students had to equate the momentum of the incident white ball to the sum of the momentum of both the white ball and the black ball after their collision. The difficulty of numerical-response 3 was less than the difficulty of multiple-choice 7. This indicated that students are able to apply the law of conservation of momentum to one-dimensional problems, and that students are willing to use the recorded answer of a previous question to answer a linked question.

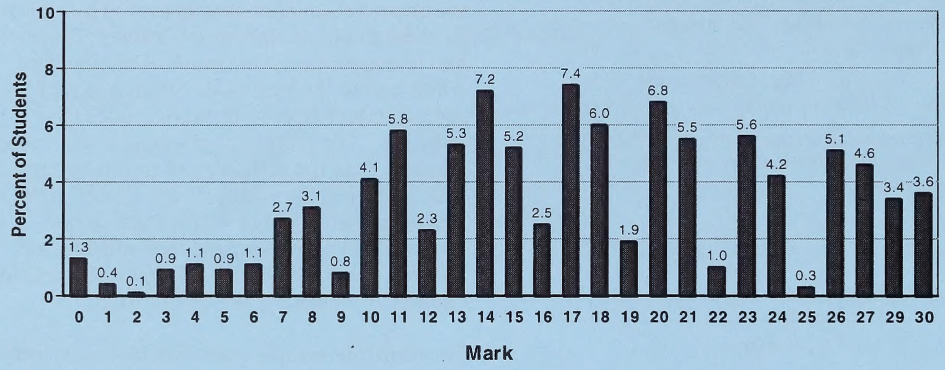
For **multiple-choice question 13**, most students who achieved the acceptable standard on the examination answered this question correctly. In order to obtain the correct answer, students had to identify that the direction of an electric field is defined as the direction that an electrostatic force would be applied to a positive test charge placed in this field. At a point midway between the charged spheres I and II, the electric field caused by charge I is to the left of the page. The electric field caused by charge II is also to the left; thus, the net electric field caused by both charges is to the left. The most common error encountered was that students identified the net field as being to the right. In this case, it is likely that these students did not correctly apply the definition of electric field direction.

For **multiple-choice question 27**, most students who achieved the standard of excellence on the examination correctly answered this question. Many students, however, demonstrated difficulty in applying the photoelectric effect to a series circuit. In order to obtain the correct answer, students had to use the information provided and the photoelectric equation to find the output voltage of one cell. By using a ratio, the students could then find the total number of cells required in series to produce a total output voltage of 12.0 V. The most common error made by students was to select the distracter B. This incorrect response is obtained by dividing the total output voltage of 12.0 V by the work function of 1.60 eV, to obtain the value of 7.5.

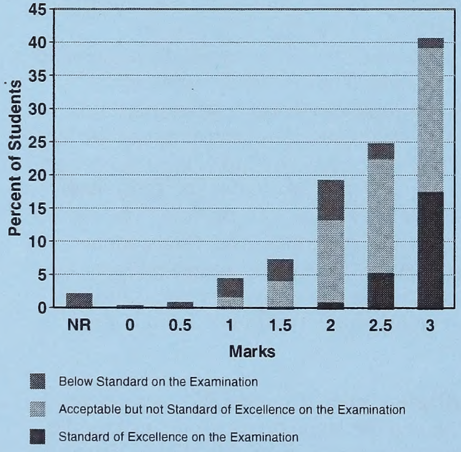
Written-Response Questions

Of all the students who wrote the January 1999 examination, 1.3% received no marks on the written-response questions, 62.2% received a mark of 15 or higher, and 20.8% received a mark of 24 or higher out of 30. The average mark on the written-response questions was 17.2, or 57.4%.

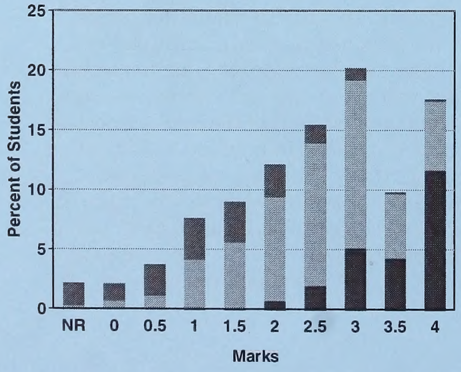
Distribution of Marks for Written Response



Distribution of Marks for Question 1 - Scale 1



Distribution of Marks for Question 1 - Scale 2



Results for **written-response question 1** indicate that the majority of students showed a good understanding of the basic properties of the photoelectric effect, electromagnetism, and the operation of simple DC circuits.

Students demonstrated an understanding of the photoelectric effect, but had difficulty applying their knowledge to the burglar alarm circuit. Misconceptions about the photoelectric effect included:

- The idea that ultraviolet light contained electrons that were reflected off the cathode, then moved to the anode.
- The idea that photons move from the cathode to the anode, then through the circuit.

The most common omission in describing the photoelectric effect was failing to address the concept that the frequency of the ultraviolet light needed to be greater than the threshold frequency of the cathode surface.

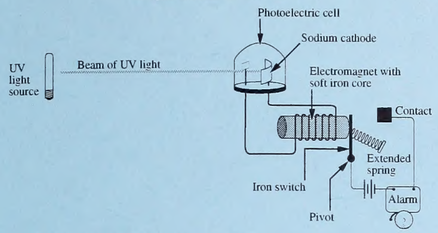
Many students provided a weak description of the operation of the electromagnet. Students often confused electricity and magnetism. Some misconceptions communicated about electromagnetism included:

- The idea that electrons move through the soft iron core.
- The idea that a magnet has positive and negative poles.
- The idea that a magnet becomes charged.
- The idea that the magnetic field was created as a result of a charge separation in the soft iron core.

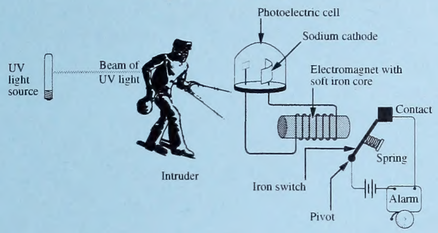
Burglar Alarm

Shown below is a simplified circuit of a burglar alarm.

Burglar alarm not activated



Burglar alarm activated



A beam of ultraviolet light is directed toward a photoelectric cell, as shown above. As long as this beam is not interrupted, light will be incident on the sodium cathode, and there will be a current in the electromagnet. The electromagnet is of sufficient strength to hold the iron switch. As a result, the alarm will not be activated.

An intruder walking between the UV light source and the phototube will cause the alarm to sound.

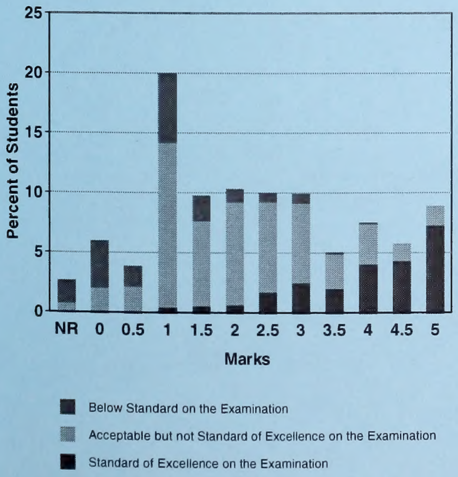
Written Response – 15%

1. Using the concepts of the photoelectric effect, Electromagnetism, and electrical circuits, analyze the operation of this burglar alarm

- when the beam of UV light is incident on the sodium cathode
- while the intruder interrupts the beam of UV light

Note: Marks will be awarded for the physics principles used in your response and for the effective communication of your response.

Distribution of Marks for Question 2



Students demonstrated a good overall knowledge of circuits. Most students recognized that the alarm circuit was in series. Some students demonstrated a misconception in their understanding of the operation of the switch. Often, students correctly communicated that a magnetic force of attraction held the switch open. However, many students attributed the closing of the switch to a magnetic repulsion, rather than recognizing that the spring pulled the switch closed.

The students who did not achieve the acceptable standard for this question often restated the information provided in the question, or they did not thoroughly address all three major concepts.

The four major concepts addressed in **written-response question 2** were data manipulation, data presentation, data analysis (slope and finding charge), and Coulomb's Law. Although many students did not know how to straighten a curve, most students attempted to address all four major concepts.

Several curve-straightening methods were acceptable. It was required that the manipulated data was placed on the horizontal axis, and that the responding data was placed on the vertical axis. A suitable data manipulation produces a linear graph.

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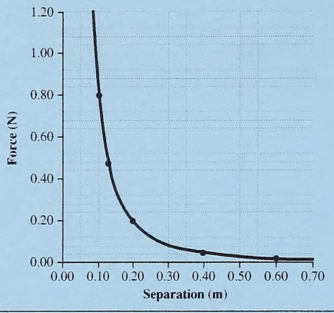
Use the following information to answer the next question.

A student performed an experiment that verified Coulomb's Law of Electrostatics by measuring the repulsion between two charged spheres, A and B, as a function of the separation of the spheres. The spheres were identical in size and mass. The measurements are shown in the table of values and plotted on the graph below.

Separation (m)	Force (N)
0.10	0.790
0.13	0.480
0.20	0.200
0.40	0.050
0.60	0.022

Force of Repulsion as a Function of the Separation



Written Response – 15%

2.
- Show that the results verify Coulomb's Law by manipulating the data and providing a new table of values that, when plotted, will produce a striaght-line graph.
- Plot the new data with the responding variable on the vertical axis.
- Calculate the slope of your graph.
- Using the slope value, or another suitable averaging technique, determine the charge on sphere B if the charge on sphere A is 3.08×10^{-7} C.
- Determine the magnitude of the force between spheres A and B when they are at a distance of 2.00 m apart. Use the hypothetical value of 3.00×10^{-6} C for the charge on sphere B if you were unable to determine the actual value.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

Many students had difficulty correctly labelling the data table and the graph axis. For example, if the inverse square of the separation was plotted on the horizontal axis, its label should be

$$separation^{-2}(m^{-2})\text{, or }\frac{1}{separation^{2}}\left(\frac{1}{m^{2}}\right)$$

Students had difficulty finding the units of the slope, and relating the slope to the unknown charge using Coulomb's Law.

Many students were successful in finding a value of the average charge despite being unable to straighten the curve. An acceptable method for finding the unknown charge was to evaluate the value of each charge, then find the average of these charges. It was not acceptable, however, for students to find the average values of separation and force, and then to use those values to find the value of the average charge.

Most students were successful in finding a value of the electrostatic force between two charges. Students used the value of the charge obtained from their previous calculation, or they used the hypothetical value provided.

For further information, contact Bob Shaw (bshaw@edc.gov.ab.ca) or Corinne McCabe (cmccabe@edc.gov.ab.ca) at the Student Evaluation Branch at (780) 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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